REMARKS

Claims 1-29 were pending of which Claims 1, 2, 9, 10, and 13-15 were rejected and Claims 3-8, 11, 12, 16, 27-29 were objected to. Claims 3, 7, 9-12, and 13 have been amended and Claims 1, 2, 17-26, and 29 have been cancelled.

The Examiner objected to Claims 3-8, 11, 12, and 16 as being dependent upon a rejected base claim, but indicated that they would be allowable if rewritten in independent form including all the limitations of the base claim and any intervening claims. Claims 3, 7, 11, and 12 have been so amended. Thus, the scope of Claims 3, 7, 11, and 12 has not been narrowed. Claims 9 and 10 have been amended to be dependent on Claim 3 so as to remain dependent on a pending claim. Claim 13 has been amended to delete "on said sample" the term "by" as surplusage. Thus, the scope of the Claim 13 has not been narrowed. No new matter has been added in the claims.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

Election/Restrictions

Applicants hereby elect Claims 1-16 and 27-29. Claims 17-26 have been cancelled.

Drawings

The drawings were objected to under 37 CFR 1.83(a) because they failed to show "labeled representation (e.g., a labeled rectangular box)" for Fig. 1, #102, 122, 126, 130, 136, and 134. Fig. 1 has been amended to include labels in #102, 122, 126, 130, 136, and 134, as described in the specification in the paragraphs starting at page 4, line 29 and ending on page 6, line 31. Thus, no new matter is added. A proposed drawing correction showing the changes in red is attached hereto as a separate letter pursuant to MPEP §608.02(r).

The drawings were objected to because #254 and 256 in Fig. 3 did not correspond to step 254 and step 256 in the specification. The drawings have been amended accordingly. Fig. 3 is amended delete box 256, change the reference number of box 254 to 256 and to include a new box 254, all of which is described in the specification at the paragraph starting on page 7, line 21 and ending on line 30. Thus, no new matter is added. A proposed drawing correction showing the changes in red is attached hereto as a separate letter pursuant to MPEP §608.02(r).

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Formal drawings will be filed incorporating these changes upon the Examiner's acceptance of the proposed drawing changes.

Specification

The Examiner rejected the abstract due to the inclusion of "in accordance with the present invention". The abstract has been amended to remove this phrase.

The Examiner objected to the specification as the term "r-θ sample stage" at page 2, lines 1-3 is indefinite. Applicants respectfully submit that the term "r-θ" is well known in the art, and that therefore an r-θ sample stage is not indefinite.

As is well known, the term "r-θ" refers to the polar coordinate system. For example, attached hereto as Exhibit A is an excerpt from a text book entitled "Calculus and Analytical Geometry" by George B. Thomas, Jr. and Ross L. Finney, reprinted in 1985 at page 570, discussing polar coordinates and the use of r and θ to define these coordinates. Thus, an "r-θ sample stage" is a stage that operates within the polar coordinate system, just as an XY stage operates in the well known Cartesian coordinate system. For example, at page 5, lines 27-29 the specification states that the metrology tool may be used with "a wafer stage 118 that is capable of any or all of the x, y, z, and/or θ movement, as well as a stage that is capable of r-θ movement only." Just as one of ordinary skill in the art would know what type of movement is being referred to when the term "x, y, z" is used, one of ordinary skill in the art would know what type of movement is being referred to when "r-θ" is used. Defining the "r" movement of the stage is no more necessary to one of ordinary skill in the art than defining the "x" movement of an x, y, z stage. Accordingly, Applicants respectfully submit that the term "r-θ sample stage" is not indefinite. Reconsideration and withdrawal of the objection is requested.

Claim Objections

Claims 12 and 27 were objected to as containing informalities. In particular, the Examiner stated that "[t]he term 'r-θ' is not defined by the claim, specification or drawings in such a way to ascertain the exact rotation involved with the term 'r'." As discussed above, it is well known that the term "r-θ" is used to describe the polar coordinate system of the stage that the sample is held on. As is well known, in r-θ (polar) coordinates, a location is defined by its position along a radius "r" and its angular position "θ". Thus, there is no rotation involved with the term "r".

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An "r-θ sample stage" is a well known type of stage that needs no further explanation to be understood by those of ordinary skill in the art. Thus, Applicants respectfully submit that the term "r-θ sample stage" is sufficiently definite and, accordingly, Applicants respectfully request reconsideration and withdrawal of the objection to Claims 12 and 27.

Claim 13 was objected to because there are two elements labeled as "(f)". Appropriate correction has been made.

Claim 13 was objected to because of the limitation "said sample" has insufficient antecedent basis. The phrase "on said sample" has been deleted from Claim 13.

The Examiner noted a warning that Claim 29 is a substantial duplicate of Claim 12. Claim 29 has been cancelled.

Claim Rejections – 35 U.S.C. §103

Claims 1, 9, and 10 were rejected under 35 U.S.C. §103a) as being unpatentable over Rosencwaig et al (US 5,596,406) ("Rosencwaig"). The Examiner also rejected Claim 2 under 35 U.S.C. §103a) as being unpatentable over Rosencwaig in view of Ledger (US 5,555,474) ("Ledger").

Claims 3, 7, 11, and 12, which the Examiner indicated would be allowable if rewritten in independent form, have been so amended. It is respectfully submitted that Claims 3, 7, 11, and 12 are now allowable. Claims 4-6 and amended Claims 9 and 10 depend from Claim 3 and are therefore likewise allowable. Claim 8 depends from Claim 7 and is therefore likewise allowable.

Claims 13 and 15 were rejected under 35 U.S.C. §103a) as being unpatentable over Rosencwaig in view of Conrad (US 5,963,329) ("Conrad"). The Examiner stated that "Rosencwaig does not seem to specifically disclose repeating steps for a plurality of orientations to determine at least one parameter." The Examiner stated that "Conrad et al. teaches repeating the steps for a plurality of orientations to determine at least one parameter (Fig. 12)." Applicants respectfully traverse.

Conrad Fig. 12 shows a line profile result for reflectivity versus wavelength. The line "profile was calculated independently from two normal polarizations, transverse magnetic (TM) and transverse electric (TE)." Col. 10, lines 37-39. Conrad states that "[t]o minimize analysis time, it is convenient to select either the TE or TM polarization. In this way only the normalized reflected intensity for a single polarization need to be calculated." Col. 10, lines 58-51. Fig. 12 shows the line profile for separate measurements using the TE polarization and

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using the TM polarization. However, Conrad does not teach that both polarizations are used together. Thus, Conrad fails to teach elements e and f from Claim 13, i.e., "producing a relative rotation between said polarizing element and said diffracting structure to alter the orientation of said polarized element relative to said diffracting structure and repeating steps a through d" and "repeating step e for a plurality of orientations of said polarizing element and said diffracting structure". Moreover, Conrad rails to teach element g, which states "<u>using said detected intensities</u> of said spectral components of said output beam <u>for a plurality of orientations</u> to determine said at least one parameter of said diffracting structure."

Consequently, the combination of Rosencwaig with Conrad does not teach all the elements of Claim 13.

In addition, Applicants' respectfully submit that the Examiner's motivation to combine Rosencwaig with Conrad is inadequate. The Examiner stated that "one would be motivated to have thorough data to check for accurate data as implied by Conrad et al. (col. 10, lines 52-55)." The referenced passage in Conrad, however, states that "the figure shows close agreement between the calculated intensity versus wavelength curves for both TE and TM. Both give almost identical line profiles." Conrad is simply showing that either polarization state may be used for the measurement. Conrad is not suggesting that a measurement should be performed at a plurality of polarization orientations. Thus, Applicants respectfully submit that there is no motivation to apply the steps of Conrad with the method of Rosencwaig.

Thus, Applicants respectfully submit that Claim 13 is patentable over the combination of Rosencwaig and Conrad. Reconsideration and withdrawal of this rejection is respectfully requested. Claims 14-16 depend from Claim 13 and are, therefore, likewise patentable.

Applicants note that Claim 14 was rejected under 35 U.S.C. §103a) as being unpatentable over Rosencwaig in view of Ledger. However, on page 9, under paragraph 15 of the Office Action, the Examiner indicated that "[r]egarding claim 14, prior art does not specifically disclose or fairly suggest generating a reference database for comparison to detected intensities in combination with all the limitations in the claim and the base claim." Applicants find this statement confusing in light of the rejection on page 8 of the Office Action. Nevertheless, as discussed above, Claim 14 depends from Claim 13, and is therefore patentable for at least the same reasons as Claim 13. Ledger does not make up for the deficiencies of Rosencwaig and Conrad.

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Claims 3, 7, 9-12, 13 have been amended and Claims 1, 2, 17-26, and 29 have been cancelled leaving Claims 3-16 and 27-28 pending. For the above reasons, Applicants respectfully request allowance of Claims 3-16 and 27-28. Should the Examiner have any questions concerning this response, the Examiner is invited to call the undersigned at (408) 982-8200, ext. 2.

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail (Label No. EU 392 272 972 US) addressed to: Commissioner for Patents, Washington, D.C. 20231, on the below date.

Michael J Halbert 6-13-02

Attorney for Applicants — Date of Signature

Respectfully submitted,

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Version with markings to show changes made

In the Claims

Claims 3, 7, 9-12, 13 are amended as follows. Claims 1, 2, 17-26, and 29 have been cancelled.

3. (Amended) An apparatus for measuring one or more parameters of a diffracting structure on a sample, said apparatus comprising: [The apparatus of Claim 2,]

a radiation source that emits broadband radiation;

a polarizing element, said radiation passing through said polarizing element toward said sample, said radiation being normally incident on and reflected off said diffracting structure on said sample, said reflected radiation passing through said polarizing element, at least one of said polarizing element and said sample are rotatable to produce a relative rotation between said polarizing element and said diffracting structure;

a spectrograph that detects the intensity of spectral components of said reflected radiation after passing through said polarizing element at a plurality of polarization orientations between said polarizing element and said diffracting structure;

wherein said spectrograph produces a spectrograph signal for said spectral components and a plurality of polarization orientations, said apparatus further comprising a computer system for analyzing said spectrograph signal to determine said one or more parameters of said diffracting structure on said sample, said computer system comprising:

at least one computer connected to said spectrograph to receive said spectrograph signal; and

a computer program executed by said at least one computer, wherein said computer program includes instructions for:

extracting spectral information from said spectrograph signal;

[wherein said computer program further comprises instructions for:]

constructing an optical model simulating said diffracting structure using at least one variable parameter;

calculating spectral information for said optical model; and

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curve fitting said calculated spectral information to said extracted spectral information to determine said one or more parameters of said diffracting structure on said sample.

7. (Amended) [The apparatus of Claim 2,] An apparatus for measuring one or more parameters of a diffracting structure on a sample, said apparatus comprising:

a radiation source that emits broadband radiation;

a polarizing element, said radiation passing through said polarizing element toward said sample, said radiation being normally incident on and reflected off said diffracting structure on said sample, said reflected radiation passing through said polarizing element, at least one of said polarizing element and said sample are rotatable to produce a relative rotation between said polarizing element and said diffracting structure;

a spectrograph that detects the intensity of spectral components of said reflected radiation after passing through said polarizing element at a plurality of polarization orientations between said polarizing element and said diffracting structure;

wherein said spectrograph produces a spectrograph signal for said spectral components and a plurality of polarization orientations, said apparatus further comprising a computer system for analyzing said spectrograph signal to determine said one or more parameters of said diffracting structure on said sample, said computer system comprising:

at least one computer connected to said spectrograph to receive said spectrograph signal; and

a computer program executed by said at least one computer, wherein said computer program includes instructions for extracting spectral information from said spectrograph signal wherein said computer instructions for extracting spectral information from said spectrograph signal comprise computer instructions for:

calculating the sample reflectance for a plurality of wavelengths of said radiation and a plurality of polarization orientations of said polarizing element relative to said diffracting structure; and

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curve fitting said sample reflectance for said plurality of wavelengths and said plurality of positions with:

$$R(\Theta) = A \cdot \cos^4(\phi - \Theta) + B \cdot \sin^4(\phi - \Theta) + C \cdot \cos^2(\phi - \Theta) \cdot \sin^2(\phi - \Theta)$$

where $R(\Theta)$ is the measured reflectance at one wavelengths, Θ is the polarization orientation of said polarizing element with respect to said diffracting structure, and ϕ, A, B, and C, measurable, to obtain said spectral information.

9. (Amended) The apparatus of Claim [1] <u>3</u>, wherein said spectrograph comprises:

a dispersing element that disperses said polarized beam into spectral components; and

an array of detector pixels that detect the intensity of said spectral components.

10. (Amended) The apparatus of Claim [1] <u>3</u>, wherein said polarizing element is a rotatable polarizing element that rotates relative to said diffracting structure.

11. (Amended) [The apparatus of Claim 1, said apparatus further comprising] <u>An apparatus for measuring one or more parameters of a diffracting structure on a sample, said apparatus comprising:</u>

<u>a radiation source that emits broadband radiation;</u>

<u>a polarizing element, said radiation passing through said polarizing element toward said sample, said radiation being normally incident on and reflected off said diffracting structure on said sample, said reflected radiation passing through said polarizing element, at least one of said polarizing element and said sample are rotatable to produce a relative rotation between said polarizing element and said diffracting structure;</u>

<u>a spectrograph that detects the intensity of spectral components of said reflected radiation after passing through said polarizing element at a plurality of polarization orientations between said polarizing element and said diffracting structure; and</u>

a sample stage, said sample being held on said sample stage, wherein said sample stage rotates said diffracting structure relative to said polarizing element.

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12. (Amended) [The apparatus of Claim 1, said apparatus further comprising] An apparatus for measuring one or more parameters of a diffracting structure on a sample, said apparatus comprising:

a radiation source that emits broadband radiation;

a polarizing element, said radiation passing through said polarizing element toward said sample, said radiation being normally incident on and reflected off said diffracting structure on said sample, said reflected radiation passing through said polarizing element, at least one of said polarizing element and said sample are rotatable to produce a relative rotation between said polarizing element and said diffracting structure;

a spectrograph that detects the intensity of spectral components of said reflected radiation after passing through said polarizing element at a plurality of polarization orientations between said polarizing element and said diffracting structure; and

an r-θ sample stage, said sample being held on said r-θ sample stage.

13. (Amended) A method of measuring at least one parameter of a diffracting structure, said method comprising:

(a) passing broadband radiation through a polarizing element to produce polarized radiation;

(b) directing said polarized radiation to be normally incident with said diffracting structure, said polarized radiation being reflected off [by] said diffracting structure[on said sample];

(c) analyzing the reflected radiation with said polarizing element to produce an output beam with a polarity orientation;

(d) detecting the intensity of spectral components of said output beam;

(e) producing a relative rotation between said polarizing element and said diffracting structure to alter the orientation of said polarized element relative to said diffracting structure and repeating steps a through d;

(f) repeating step e for a plurality of orientations of said polarizing element and said diffracting structure; and

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[(f)] (g) using said detected intensities of said spectral components of said output beam for a plurality of orientations to determine said at least one parameter of said diffracting structure.

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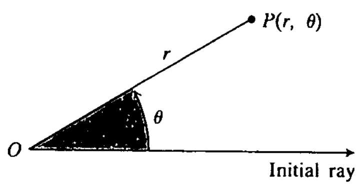
10 Polar Coordinates

10.1
Polar Coordinates

One of the original ideas offered by Newton's *The Method of Fluxions and Infinite Series* (written about 1671 but not published until 1736) was the use of new coordinate systems, among them the system of polar coordinates that locates points by reference to what we might call their distance and compass direction from a fixed point. Polar coordinates are important because in polar coordinates the conic sections are all given by a single equation. We shall explore this amazing fact in Article 10.3. The polar equation for conic sections is important in physics and astronomy, where it arises in the study of planetary motion and the derivation of Kepler's three laws.

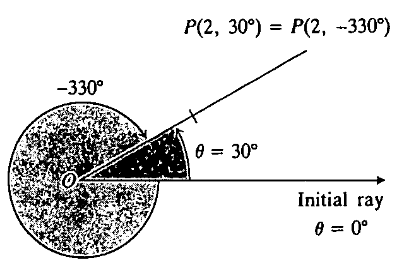


10.1 Polar coordinates.

To define polar coordinates we first fix an *origin* O and an *initial ray* from O, as shown in Fig. 10.1. Then each point P can be assigned *polar coordinates* (r, θ) in which the first number, r, gives the directed distance from O to P and the second number, θ, gives the directed angle from the initial ray to the segment OP:

$$P(r, \theta) \qquad (1)$$

Directed distance from O to P — Directed angle from initial ray to OP.



10.2 The ray $\theta = 30°$ is the same as the ray $\theta = -330°$.

As we shall see, each point in the plane has many different coordinate pairs.

As in trigonometry, the angle θ is *positive* when measured counterclockwise and negative when measured clockwise (Fig. 10.1). But the angle associated with a given point is not unique (Fig. 10.2). For instance, the point 2 units from the origin, along the ray $\theta = 30°$, has polar coordinates $r = 2$, $\theta = 30°$. It also has coordinates $r = 2$, $\theta = -330°$, and $r = 2$, $\theta = 390°$.

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